ENERGY STAR® Label for Buildings

Technical Description

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I. THE BENCHMARKING TOOL

Tool Application

The Benchmarking Tool may be used to evaluate energy use and obtain a benchmark score only for individual buildings independently metered for all energy uses. For buildings with multiple space uses that are commonly metered, the Benchmarking Tool evaluates energy use by defining primary and secondary space types and uses a weighted average (by floor area) to evaluate each space use. Primary space types (defined as the building's primary functions) available to date include office space. Secondary space types are incidental to the building's primary operations (but not separately metered). Secondary space types available to date include data centers/computer rooms and parking facilities. The Benchmarking Tool can currently evaluate buildings with multiple occurrences of one primary space use (office) and multiple occurrences of two secondary space types (data centers with separate HVAC systems and parking facilities).

To evaluate a building with the Benchmarking Tool, the building may be characterized by dividing its primary and secondary spaces based on their operations and occupancy. For example, a building's office space may be subdivided into several primary space types based on unique operating hours, occupant densities, or personal computer loads. Other spaces on the same electric meters, such as open parking lots, covered parking garages, and data centers/computer rooms, would be defined in the tool as separate secondary spaces. Buildings with the space uses listed above may be benchmarked within the following parameters:

- Minimum building size of 5,000 gross square feet
- Minimum of 50 percent of gross square footage for primary space use (office), with no more than 49 percent of gross square footage as secondary use space (data centers/computer rooms and covered, vented garages)
- No more than 10 percent of gross square footage may be data centers/computer rooms with dedicated HVAC system
- Vacancy rate may not exceed 20 percent in primary spaces.
- Occupancy hours must be a minimum of 30 hours per week in primary space
- Must be open at least 11 months a year
- Must consume electricity

For purposes of providing an accurate comparison of energy performance against similar building types, buildings outside of these characteristics may not be evaluated by the Benchmarking Tool at this time. Additional primary and secondary space uses are under evaluation for future inclusion into the tool.

Inputs and Outputs

The Benchmarking Tool requires certain data to be entered to calculate the Benchmark Score. At a minimum, the following numeric inputs are required to complete the calculations and produce a fully developed Building Results page. Note that other pertinent non-numeric information (name and address of Building Owner, Building Sponsor, etc.) is also required to produce a Statement of Energy Performance and apply for the Label:

1. Breakout of space uses within the building (currently limited to office, data centers/ computer rooms, and parking areas)
2. Gross floor area per space use
3. Weekly hours of operation per space use
4. Number of occupants per space use (office space only)
5. Census of personal computers (office space only)
6. Monthly energy use for the most recent 12 continuous months

Multiple Meters

For buildings with multiple meters, each meter may be entered separately. All energy sources can be accepted. Electricity, natural gas, oil, district steam, coal, propane, and district chilled water are called out explicitly. Any other energy sources may be entered as "other." All annual meter data must overlap no more than 410 days—beginning with the first metered day on the oldest month to the last date on the most recently metered month.

Source Energy

The Benchmarking Tool applies a source (or primary) energy conversion. In this case, electricity is assigned a national heat rate of 10,300 Btu/kWh. This correlates to an average power plant efficiency of 33 percent. Source energy is used as it is a better indicator of both cost and environmental impact compared with site energy.

Renewable Energy and Cogeneration

On-site renewable energy is recognized by virtue of the fact that less off-site energy is purchased. Off-site renewable energy does not receive special treatment. Cogeneration is recognized by virtue of the fact that less source energy is consumed. This is only true, however, if the overall cogeneration efficiency is greater than 33 percent.

Weather Adjustments

Users must enter monthly energy use for each meter. Monthly data allows for variations in monthly outdoor temperatures to be normalized from one year to another.

Benchmarking Score

The Benchmarking Tool produces a score on a 1 to 100 scale. ENERGY STAR is defined as 75 or higher, indicating energy performance better than 75 percent of similar buildings. A score of 37, for example, would indicate energy performance better than only 37 percent of similar buildings.

II. INDOOR ENVIRONMENT CRITERIA

The Benchmarking Tool does not make assessments about comfort or indoor air quality. For the purposes of achieving the ENERGY STAR Label for Buildings, the building's primary space types will be required to meet minimum requirements for control of indoor

pollutants, supply of outside air, thermal comfort, and light levels. These requirements will be verified by inspection by a licensed professional engineer or registered architect.

The control of indoor air pollutants and minimum outside air supply is based on elements of the provisions in American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 62-1989, *Ventilation for Acceptable Indoor Air Quality*. Thermal comfort conditions for relative humidity and temperature are based on the elements of the provisions in ASHRAE Standard 55-1992, *Thermal Environmental Conditions for Human Occupancy*. Illuminance levels are based on the Illuminating Engineering Society of North America, IESNA Lighting Handbook – *1993 Application Volume*, Illuminance Selection Procedure. Licensed Building Professional Guidance (professional engineers, registered architects currently under consideration) has been produced outlining suggested field assessment methodologies.

Control of Indoor Pollutants

Each of the following space uses require **direct exhaust** of the room/source air to the outdoors; space under **negative pressure** relative to occupied spaces; and any containers fully sealed:

- Printing facilities or large copy rooms
- Cooking facilities
- Smoking lounges (60 cubic feet per minute (CFM)/person outside air makeup)
- Enclosed garages (1.5 CFM/sf outside air makeup)
- Chemical storage rooms/facilities (e.g., spaces that store housekeeping supplies, pesticides, paints, lubricants, adhesives)
- Rest rooms
- Repair shops/machine rooms
- Laboratories
- Dry cleaning facilities

Other indoor pollutant control requirements:

- The building shall have a **smoking policy** that prevents involuntary exposure to secondhand smoke by either prohibiting smoking or restricting smoking to areas that are separately ventilated, maintained under negative pressure, and directly exhausted to the outside as recommended in ASHRAE Standard 62-1989.
- The building also should have a **written preventative maintenance program**. The licensed building professional will examine the building documentation for a written maintenance schedule that includes monitoring, inspecting, and cleaning of HVAC components. If a written plan is not present, the licensed professional will suggest that one be considered. Details for setting up and implementing a preventative maintenance program can be found in *Building Air Quality: A Guide for Building Owners and Facility Managers* (EPA/400/1-91/033, DHHS (NIOSH Pub. No. 91-114)), and *Building Air Quality Action Plan* (EPA 402-K-98-001, DHHS (NIOSH Pub. No. 98-123)).
- The building should be free of **microbiological sources** as indicated by no stained ceiling tiles, wet carpets or other porous materials, and musty odors. Air handling unit drain pans should be clean and properly sloped. HVAC components downstream of water sprays must be clean. Cooling towers must be clean with no musty odors.

- **Combustion sources** such as furnaces shall be exhausted directly to the outside and shall be assured of no back draft.
- **Outdoor air intakes** should be visually determined to be adequately protected from outdoor sources such as cooling tower exhaust, street traffic, trash storage, and building exhaust from same or adjacent buildings

Supply of Outside Air

The amount of outside air required for office space is 20 CFM per person. This minimum requirement is to be met by all air handling units representing average volume delivered to all occupants in the primary space.

Thermal Comfort

Thermal comfort requirements are:

- Occupied spaces measured between 68^{o}F and 79^{o}F, 68^{o}F Wet Bulb max summer, 64^{o}F Wet Bulb max winter, 37^{o}F Dew Point min as per ASHRAE 55-1992
- Little evidence of outside fans and heaters brought in by occupants that would indicate significant occupant thermal discomfort

Light Levels

Light levels shall meet minimum horizontal illuminances (in foot-candles) established in the table below.

Open Parking and Pedestrian Facilities	
High activity	0.9
Medium activity	0.6
Low activity	0.2

Covered Parking and Pedestrian Facilities (averages on pavement)	Daytime/Nightime
General areas	5/5
Ramps and corners	10/5
Entrance areas	50/5

Hallways and stairwells measured at ground level	5
Working spaces where visual tasks are only occasionally performed	10
Ambient lighting for computer use	20
Visual tasks of high contrast or large size (office)	20
Visual tasks of medium contrast or small size	50
Visual tasks of low contrast or very small size	100

III. THE STATEMENT OF ENERGY PERFORMANCE

The Statement

The Statement of Energy Performance documents whole-building performance for both actual and normalized energy use and costs, and indoor environment. Energy perform-

ance is also benchmarked (scored on a 1-100 scale) against all similar use buildings in the United States. Total costs for energy consumption and demand for both the actual energy performance and ENERGY STAR target level of performance are estimated using current fuel costs, and normalized for weather effects.

Atmospheric air pollution associated with the building's energy consumption and the ENERGY STAR target is based on the following factors: state carbon dioxide (CO_2) emissions factors, EPA regional sulfur dioxide (SO_2) and nitrogen oxides (NO_x) emissions factors from electricity generation, and national CO_2, SO_2, and NO_x emissions factors from on-site consumption of natural gas and oil. At this time, these figures do not account for steam, propane, district chilled water, coal, kerosene or other energy source pollution contributors.

Indoor environment performance is assessed on a pass/fail basis against provisions from industry standards. Energy performance and indoor environment are assessed and verified by an on-site evaluation by a professional engineer.

Licensed Professional Verification

Energy consumption and indoor environmental conditions may be verified by a professional engineer licensed to practice in the state where the building is located (or allowed to practice in this state through state-to-state reciprocity arrangements). This verification is necessary for application for the Label and is indicated by a stamp on the Statement of Energy Performance. Participation by registered architects is under evaluation at this time. Refer to the Licensed Building Professional Guidance document for further information on their role.

IV. DERIVATION OF THE BENCHMARKS

To evaluate energy use and compare a building with its peers, the Benchmarking Tool separates primary and secondary space types. Ideally, this is done by parsing the energy use associated with the primary space from the energy use associated with the secondary space. In reality, the energy consumption of these spaces is often recorded on the same meter and is impossible to separate. The benchmarking methodology only allows primary spaces to be compared and ranked against the national building stock. Engineering estimates are established to define performance target allowances for energy use in associated secondary spaces. Thus, it is possible to benchmark an office space that includes a parking garage, but it is not possible to benchmark a parking garage independently. The following explains how the performance targets for each space use were derived.

Background of Data

The data used as the basis of the Benchmarking Tool is obtained from the US Department of Energy's (DOE) Commercial Buildings Energy Consumption Survey (CBECS). CBECS is a national, statistically based survey on building features, energy consumption, and energy expenditures in US commercial buildings. Most recently completed in 1995, DOE's Energy Information Agency (EIA) collects basic statistical information about energy consumption and energy-related characteristics of commercial buildings in the United States. Using an in-person survey, EIA collected information such as: the physical characteristics of

the building; building use and occupancy patterns; major equipment used; and types and uses of energy in the buildings. Actual energy consumption data for each building is provided by the energy suppliers (e.g., utility companies). CBECS classifies buildings by the principal activity that occurs in the building, grouping commercial buildings into 1 of 12 categories. These categories include: mercantile and service (e.g., retail); office; warehouse; education; public assembly; lodging; religious worship; health care; food service; public order and safety; food sales; vacant; and other.

The datasets of buildings classified as *office* buildings in the 1992 and 1995 CBECSs were combined by DOE and EPA to derive the algorithms used within the Benchmarking Tool. The combined dataset contains a survey sample of nearly 2,000 office buildings that statistically represents the entire spectrum of more than 700,000 commercial office buildings. The data were put through a process known as a step-wise linear regression to identify: 1) the drivers of building energy consumption (e.g., physical characteristics, building use, occupancy patterns, etc.); and 2) the relative impact of these drivers on energy consumption.

For more information on the CBECS data and other EIA publications, go to www.eia.doe.gov.

Office Space

Office space is currently the only primary space that may apply for the ENERGY STAR Label for Buildings. Energy performance data for office buildings were captured from both CBECS 1992 and CBECS 1995 (see above). The following filters were applied to the roughly 2,600 records available.

1. HDD=CDD=0 were eliminated
2. Months in use < 11 were eliminated
3. Floor area <5,000 sf or >1,000,000 sf were eliminated
4. Hours of operation < 30 per week were eliminated
5. Occupancy density < 0.3 per 1000 sf or >10 per 1,000 sf were eliminated
6. NULL entry for number of PCs was eliminated
7. NULL entry for annual energy use was eliminated
8. All observations where source energy use intensity is less than 50 or greater than 1,000 were eliminated
9. All observations reporting less than 80 percent of square footage as office space type were eliminated
10. All observations with missing values for any of the independent variables were eliminated

The resulting records numbered 1,836. Records with floor area greater than 1,000,000 sf were eliminated due to a high degree of averaging within CBECS for such buildings. Within the resulting 1,836 records, a linear regression analysis was performed using the following predictive model:

Annual Energy Use per floor area =
$C_0 + C_1$ *LN(floor area) + C_2 *CDD + C_3 * Hours of Operation + C_4 * Occupants per 1,000 sf + C_5 * PCs per 1,000 sf

Number of PCs was taken as the average of the range recorded in CBECS. The resulting regression coefficients and statistics found in Table 1 were generated using SAS™ version 6.12.

Table 1

Dependent Variable: SRCEUI

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Prob>F
Model	5	1383250173.5	276650034.7	56.326	0.0001
Error	1830	8988183651	4911575.7		
C Total	1835	10371433825			

Root MSE	2216.20752	R-square	0.1334
Dep Mean	201.66496	Adj R-sq	0.1310
C.V.	1098.95516		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	T for H0: Parame-ter=0	Prob > |T|
INTERCEP	1	-42.215466	29.39908766	-1.436	0.1512
LSQFT	1	14.966862	3.06299971	4.886	0.0001
CDD	1	0.011632	0.00386590	3.009	0.0027
WKHRS	1	0.516879	0.10906218	4.739	0.0001
OCCP1KSF	1	16.765966	2.31243703	7.250	0.0001
PCP1KSF	1	9.759413	1.38891257	7.027	0.0001

The regression model was estimated using the adjustment weights provided in the CBECS data set. This model is used in the Benchmarking Tool to normalize the building's source energy use intensity for comparison purposes. In this way both the user's building and the distribution of similar use buildings can be compared.

From the filtered and normalized data set of CBECS buildings, a weighted frequency distribution was calculated. The distribution was shifted to remove computer room influences. The percentile rankings of the distribution were calculated and are used in the Benchmarking Tool to find the building score, representing how well the applicant's building performs compared with this distribution of similar use buildings. For example, a score of 55 indicates that a building's source energy performance is better than 55 percent of similar buildings.

Secondary Space Types

If the energy use from the allowable secondary spaces cannot be separated from the primary space energy use, the Benchmarking Tool calculates an energy use allowance based on engineering estimates of energy necessary to provide adequate service using reasonably efficient equipment.

Data Centers/Computer Rooms

If the user's building contains space that is a data center or computer room with a separate HVAC system, the Benchmarking Tool calculates the energy use of this secondary space type at 359.5 source kBtu per square foot.

To evaluate the impact of data centers/computer rooms, data was analyzed from the 1997 BOMA Experience Exchange Report, from actual office buildings, and from technical representatives of data center/computer room air-conditioning equipment. Because of the increase in the power of personal computer technology, the area for a dedicated data center/computer room in office buildings today is less than 1 percent of gross building area. The following calculation determines the contribution of the annual source energy use of data centers/computer rooms:

Crrep x RATEcr = Source energy from Data Centers/Computer Rooms

Where: Crrep = Data Center/Computer Room size reported by user
RATEcr = Energy Use Intensity of Data Centers/Computer Rooms
= 359.47 kBtu/sf-yr

The resulting annual source energy is added to the overall benchmark target.

Parking Facilities (Vented and Unvented Garages, and Open Parking Lots)

If the building contains a covered parking garage (lighted and mechanically ventilated, or lighted and unventilated) and/or an open parking lot (lighted) that is *not separately metered*, the Benchmarking Tool calculates the site power density of these secondary space types at 1.46, 0.26, and 0.025 watts per square foot (watts/ft^2), respectively. These energy consumption allowances are derived, as discussed in the following paragraphs, using established engineering standards for fan power, outdoor ventilation, and lighting power allowance. The total power density multiplied by the estimated annual operating schedule results in an annual energy consumption that is added to the overall benchmarked target weighted by floor area.

For enclosed parking garage areas, ASHRAE standards and IESNA guidelines provide target values of ventilation air and illumination levels of 1.5 cubic feet per minute (CFM) per square foot and 5 footcandles (FC). The basis for the garage ventilation rate per unit area is ASHRAE Standard 62-1989. The maximum fan motor power for a constant volume fan, based on the ventilation requirements cited in ASHRAE Standard 90.1-1989, is 0.8 watts per CFM. Thus, the fan power for an enclosed parking garage area is:

$$0.8 \text{ watts/CFM} \times 1.5 \text{ CFM/ft}^2 = 1.2 \text{ watts/ft}^2.$$

Deriving a lighting energy allowance for parking garages that are master metered with primary space requires calculating a lighting power density that a reasonably efficient lighting system would require to provide the minimum horizontal illuminance requirements. The IESNA illuminance recommendations for covered parking garages is 5 FC average on the pavement, while maintaining a minimum uniformity ratio of 4:1. ASHRAE 90.1-1989 prescribes a maximum lighting power density allowance of 0.26 watts/ft^2 for garage buildings with pedestrian parking areas as the building-specific space function. Linear fluorescent, metal halide, and high pressure sodium lighting systems are all capable of delivering this IESNA target illuminance at a power density of 0.26 watts/ft^2.

Thus, an enclosed parking garage would have an annual energy allowance for the combined (fan + lighting) system of:

$$1.2 \text{ watts/ft}^2 + 0.26 \text{ watts/ft}^2 = 1.46 \text{ watts/ft}^2.$$

If this parking garage was operated for 80 hours per week, the enclosed ventilated parking garage annual energy use would be:

$$1.46 \text{ watts/ft}^2 \times 80 \text{ hours/week} \times 52 \text{ weeks/year} = 6.07 \text{ kWh/ft}^2\text{-year}.$$

An unventilated parking garage, also operating 80 hours per week, would have an annual energy use of:

$$0.26 \text{ watts/ft}^2 \times 80 \text{ hours/week} \times 52 \text{ weeks/year} = 1.08 \text{ kWh/ft}^2\text{-year}.$$

For open parking space, IESNA recommended minimum and average illuminance levels for vehicle and pedestrian low-activity were assumed, with a recommended average-to-minimum uniformity ratio of 4:1 or less. Reasonably efficient equipment with good color rendition and glare control was also assumed (flat lens Type III or Type V, 70 percent efficient luminaires, with either metal halide or high pressure sodium lamps), with a design based on either 18 or 30 foot-high poles. The power density allowance to meet these service requirements with this equipment and design is 0.025 watts/ft^2. Operating 80 hours per week, the annual energy for the outdoor lighting system would be 0.1 kWh/ft^2-year.

Calculating the Building Score

For the part of the building that is office space, square footage is multiplied by 105 to produce the nominal target annual kBtu. From the provided building characteristics, an office weighting factor based on the regression model is applied to the nominal target annual kBtu to calculate a normalized office energy use. The target consumption is calculated as the sum of the normalized office energy use and the energy allowances for reported data centers and parking facilities. Dividing by the total floor space yields the target source EUI. The building's source EUI is obtained by dividing the normalized energy used by the office space by the reported office floor space. Using a look-up table, the building's source EUI is used to identify the corresponding building score for the building's reported energy perform-

ance. A score of 75 or better represents a building that qualifies for the ENERGY STAR Label. A Licensed Building Professional must verify the results.